U. Michigan

05627-12-P

High Altitude Engineering Laboratory
Department of Aerospace Engineering

Program in Aeronomy
Status Report

Contract No. NASr-54(05)
1 Dec 65 to 28 Feb 66

Abstract

A conference report by E. J. Schaefer on the neutral composition of the upper atmosphere was issued as a U. of M. scientific report. A letter to the editor of J.G.R. on the detection of low mass ions in the arctic upper atmosphere was submitted by E. J. Schaefer and J. Brown. (This letter was later withdrawn.)* Two papers by E. K. Miller on the electromagnetic kinetics of a cylinder immersed in a plasma were submitted to Radio Science and accepted. One of these was accepted for the spring meeting of URSI.

Ambient ion densities computed from recent massenfilter flight data agreed well with electron densities from ionsonde data. Ion source development continued and the planar grid design appears promising. Initial tests of filaments coated with lanthanum hexaboride yielded encouragingly low power and temperature values. Four massenfilter composition payloads were under construction and modification of two to measure and identify low-mass ambient ions is nearing completion.

Development of electronic circuitry for measuring ambient electron densities by plasma resonance techniques is well underway.

Analysis of three August falling sphere soundings was commenced with receipt of radar data. The FPQ-6 radar data was found to be good throughout the entire altitude range. The FPS-16 data suffered beyond 85 km due to its lower signal-noise ratio. The better FPQ-6 data promises resolution of more atmospheric fine structure. Three additional sphere flights were launched in this report period. Three of the six spheres operated normally. Of the other three, one was lost until late on the downleg and two apparently had leaks. Nevertheless, essentially complete data analysis is expected from each flight.

Analysis of the thermal fine structure of the mesosphere and lower thermosphere continued with the single dimensional modeling of photochemical processes and eddy and molecular diffusion in a stable mixed atmosphere containing atomic oxygen.

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*Note. In the next report interval it was learned that the indication of low mass ions was an instrumental error and plans to investigate further such ions have been dropped. This report, however, was written in the context that the light ions were real.

I. Papers and Reports

A paper entitled "Neutral Composition," by E. J. Schaefer delivered at the University of Illinois (see 05627-11-P) was issued as scientific report University of Michigan, ORA 05627-3-S.

A paper entitled "The Excitation of Surface Currents on a Plasma-Immersed Cylinder by Electromagnetic and Electrokinetic Waves: I, The Vacuum Sheath," was submitted and accepted for publication in Radio Science. The paper is a portion of the doctoral research of Dr. Edmund K. Miller and was co-authored with Professor A. Olte of the Radiation Laboratory. Part II will be submitted to Radio Science in the next quarter.

An abstract of a paper for presentation at the 1966 Spring URSI meeting also was submitted and accepted during this report period. The title is: "The Scattering of Electromagnetic and Electrokinetic Waves Obliquely Incident on an Inhomogeneously-Sheathed Plasma-Immersed Cylinder," by E. K. Miller.

II. Composition

1. Data

Ambient ion current data obtained from NASA 14.11, 18 February 1965, 1409 hrs. local time, were converted to ambient ion densities. Calculations were based on the assumption that the instrumentation swept a column of ambient ions at a temperature equal to the 1962 U. S. Standard for the particular altitude and leaving a cross-section equal to the projection of the inlet port on the velocity vector. The results were compared with ambient electron densities calculated by the ionosphere structures section of NBS, Boulder, Colorado from Fort Churchill ionosonde data. Above 150 km there was very close agreement between the two sets of data when the low mass ion current was included in the calculations.

Below 150 km, the total ambient ion densities derived from the flight differed from the ionosonde-based electron densities by about an equal percentage depending on whether the low mass ion was included or not. In general, the better agreement at all altitudes is obtained when the low mass ion is included which lends support to its real existence.

A similar check for the nighttime flight, NASA 14.95, 19 February 1965, 0318 local time, is not possible because strong E region reflections blanketed echoes from higher regions.

2. Instrumentation

2.1 Ion Source. The elements of the planar ion source (see 05627-11-P) were interchanged so that the 86% transmission gold mesh grid was mounted between the 1/2" long 0.003 rhenium filament and the inlet port. Grid-inlet port spacing was 0.3". The sensitivity obtained was comparable with the previous ion sources yet filament power was reduced from 18 to 3 watts.

A 5-mil rhenium wire was dipped in lanthanum hexaboride (LaB_6). A few crystals adhered and the filament was tested. Emission occurred at a much lower temperature and 4 ma emission was obtained with only 2 watts heating power for the 5/8" long filament. Cycling up to atmospheric pressure and back down again produced no noticeable effect on emission. Obtaining a proper LaB_6 coating with good adhesion is a problem requiring solution.

It was decided to convert two units to an ambient positive ion analysis, restricting operation to the range below mass 6, approximately. Thus switching transients would be eliminated and low-mass resolution would be improved. In this manner it was hoped to verify and identify the low-mass ions over Fort Churchill. Accordingly, two 4.8 MC oscillators were designed, built and bench-checked.

Analyzing sections of four massenfilters were completed and assembled. In an attempt to obtain cleaner surfaces, plating of the ion source components was started in the laboratory. Initial results were quite satisfactory but trouble was encountered in subsequent plates in which the gold tended to flake off. The difficulty was traceable to a poor commerical foundation nickel plate. Steps are underway to do this process in the laboratory also.

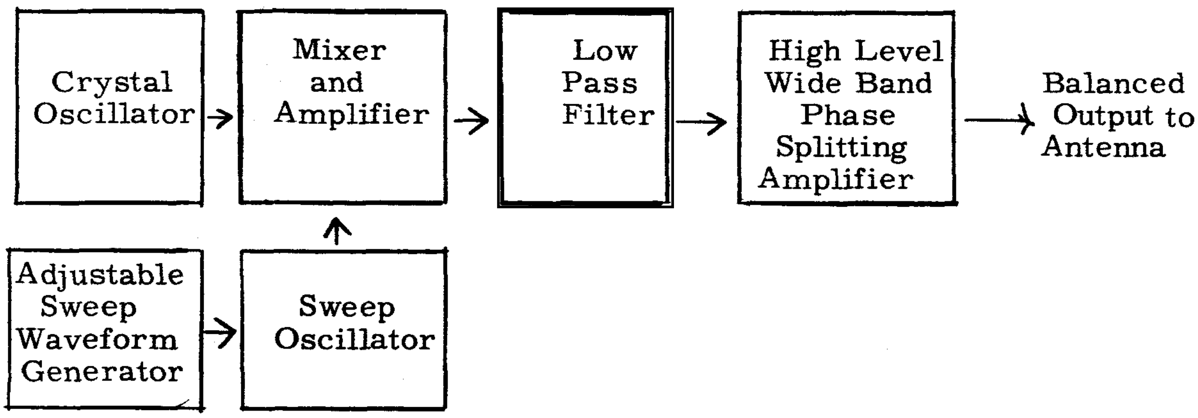
Three vacuum cans manufactured by a process in which the ribs are firmly located prior to oven-braze operations, were found to be "tight" when received. A fix was accomplished by forcing the old jig into the can and then stress-relieving the entire assembly in a hydrogen oven. After some difficulties were encountered and fixed successful aerodynamic heating tests of these units was accomplished.

Construction of four payloads continued. The conversion of two of these to exclusive analysis of low-mass ambient ions is underway.

III. Electron Density Measurements

In September 1966, enough preliminary investigation of the technique of measuring electron density by the detection of plasma resonance relaxation had been accomplished to enable the laboratory development of practical measuring instrument to begin. The system consists of three parts, a short dipole antenna, a high level balanced output sweep frequency excitation generator and a low level difference frequency tracking detector. The initial breadboard circuit development is designed to operate over a frequency range of from 300 kHz to 10 mHz. This coverage of plasma frequencies is equivalent to electron densities of 1.1×10^3 to 1.2×10^6 electrons/cc. Electron densities in the 100 to 250 kilometer altitude interval are always expected to be within this range.

At the end of this reporting period, all portions of the block diagram were operating in breadboard form with the exception of the sweep waveform generator and the final circuitry for automatic gain control of the wide band phase splitting amplifier. In the next quarter, we expect to finish these items and measure performance characteristics of the complete sweep frequency excitation generator. An engineering model of the generator and initial design, fabrication and testing of portions of the detector system are also planned for the next quarter.



HIGH LEVEL SWEEP FREQUENCY EXCITATION GENERATOR

Analytical work planned for the next quarter will be concerned with the application of numerical analysis techniques and the development of computer programs for the study of plasma immersed antenna impedance variations as the antenna operating frequency is varied from below to above the plasma frequency.

In January 1966 Edmund K. Miller (Ph.D., E.E., U. of M., 1965) joined the project staff and will be concerned with extensions of the theory of antenna-plasma interactions and the physics of the ionosphere.

IV. Spheres

Radar data from the August soundings, NASA 10.154 UA, 10.169 GM, and 10.157 UA was delivered in December and analysis was commenced.

These three soundings are of interest because they measure atmospheric diurnal changes in a 24 hour period and also because each sphere was tracked by both FPS-16 and FPQ-6 radars.

A preliminary finding was that heating effects at the 90 to 100 km level persist as late as 2240 hours. Grenade soundings, NASA 10.168, 10.169, and 10.170 GM, conducted by Goddard Space Flight Center, were also done in this 24 hour period. When the grenade data become available further analysis will be possible.

When density and temperature profiles obtained from each sphere tracked by the two different radars were compared it was found that the FPS-16 data agreed very well with the FPQ-6 data up to an altitude of about 85 km. Above 85 km significant differences were seen apparently due to inaccurate tracking by the FPS-16 at long range. It is known that a maximum range in a typical trajectory the FPS-16 signal to noise ratio is approximately one when tracking a 2/3 meter sphere. Range is not a critical factor in the FPQ-6 track due to its much greater power. In all cases the quality of the FPQ-6 track was found to be good. It appears that the amount of smoothing used when processing the data can be reduced for FPQ-6 data. Less smoothing enables the system to resolve smaller scale atmospheric structure.

On 16 December 1965 a falling sphere sounding was conducted by Eglin Air Force Base personnel supporting the Gemini 7 landing. Data processing and interpretation services were performed at the request of the Manned Spacecraft Center.

On 24 January 1966 Nike Cajun NASA 10.158 UA was launched at 2052 EST at Wallops Island, Virginia. This sounding was to be the first of three to measure diurnal effects in the winter atmosphere.

The second sounding, scheduled for 0340, was canceled due to jet winds aloft. On 3 February 1966 Nike Cajuns 10.159 and 10.143 UA were launched at 1331 and 2054 EST. This was the earliest date possible due to adverse weather conditions at Wallops Island. The 0340 sounding was eliminated because it was thought that the two rockets available could be used to best advantage during the afternoon and early evening hours of greatest thermal change.

Two spheres were ejected on each sounding so that the FPS-16 and FPQ-6 radar could each track a separate sphere. It was thought that the independent measurements would be helpful to interpret any anomolous effects that might be found. Of the six spheres three performed as expected with sphere deflation at $18\frac{1}{2}$ minutes near 28 km altitude. Vehicle 10.159 UA underperformed, its maximum altitude was 130 km compared to 169 km reached by 10.158 UA which was considered normal. There were indications that the low performance was caused by instability which increased drag. The FPS-16 failed to acquire its sphere, possibly due to unfavorable vehicle orientation at the time of ejection. When finally acquired at approximately 14 minutes this sphere was deflated. The second sphere, tracked by the FPQ-6 performed well. It is believed nearly all the desired data will be provided by the second sphere. The first sphere ejected from the last vehicle, 10.143 UA, deflated early at $7\frac{1}{2}$ minutes. The second sphere tracked by the FPQ-6, apparently had a small leak and deflated at $12\frac{1}{2}$ minutes, near 37 km. It is believed that the second sphere will provide nearly all the desired data.

The computer program for processing falling sphere data was translated into Fortran to facilitate its use by other experimenters. This was done to relieve pressure from other users of the falling sphere system who request data processing services.

V. Mesospheric Structure

An understanding of the thermal structure of the mesosphere and lower thermosphere can be achieved by studying the combined effects of energy-transport associated with the transport of atomic oxygen, solar heating in the extreme ultraviolet, infrared ratiation, thermal diffusion, and heat conduction. The study during this period was aimed at a better understanding of the energy budget and, consequently, the thermal structure of the region. It is known that "chemical heating" resulting from recombination of atomic oxygen plays a significant role in the seasonal variation of the mesospheric temperature. Thus the rate of dissociation of molecular oxygen for various zenith angles has been calculated, using temperature and number density profiles from the U. S. Standard Atmosphere, and absorption cross-sections tabulated by Hinteregger. Fluxes of molecular diffusion for both atomic and molecular oxygen have been calculated for a model atmosphere. Preliminary results indicate that molecular diffusion may provide a mechanism for the upward transport of atomic oxygen from its source region.

Effort is being devoted to the study of the time-variation of atomic and molecular oxygen in the region of interest by considering the effect of photochemical processes, and eddy and molecular diffusion in a stable, mixed main atmosphere. The complexity of the problem dictates that the study be limited to the vertical dimension.

VI. Fiscal Information

Amount of Contract			$1,051,000.00
Transactions to 30 November 1965		$933,581.36	
Transactions 1 December 1965 to 28 February 1966			
Salaries and Wages	$60,010.36		
Overhead	27,590.87		
Materials and Supplies	12,901.47		
Travel	2,094.99		
Equipment	8,580.54		
Subcontracts	---------		
Total		$111,178.59	
Total Transactions to 28 February 1966			$1,044,759.59
Balance as of 28 February 1966			$ 6,240.41

Respectfully submitted,

L. M. Jones

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